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A HIGH-P_T TRIGGER FOR THE HERA-B EXPERIMENT

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We have constructed a high-p_T trigger for the HERA-B experiment at DESY. The HERA-B experiment produces B mesons by inserting wire targets into the halo of the proton beam circulating in HERA. The high-p_T trigger records events that contain tracks that have high transverse momentum with respect to the beam. Such a trigger is efficient for recording $B \to \pi^+\pi^-$, $B \to K^-\pi^+$, $B_s \to K^+K^-$, $B_s \to D_s^-\pi^+$, and other topical hadronic B decays. These decays provide sensitivity to the internal angles α and γ of the CKM unitarity triangle, and they also can be used to measure or constrain the B_s-$\bar{B}_s$ mixing parameter x_s.

1. Introduction

The construction of a high-p_T trigger is an attempt to broaden the physics reach of the HERA-B experiment beyond it's main goal of measuring sin2β through the decay mode $B^0 \to J/\psi K_s^0$. Some of the possibilities include measurement of the angles α and γ through hadronic B decays such as $B^0 \to \pi^+\pi^-$, π^-K^+ and $B^0 \to \pi^\pm K^\mp$, $D^{*+}\pi^-$, respectively.[1] In addition, this trigger can be useful to constrain the B_s-$\bar{B}_s$ mixing parameter x_s.

The HERA-B experiment produces b mesons and baryons by colliding 920 GeV/c protons in the HERA storage ring with 4-8 fixed wire targets. The nominal interaction rate is 20-40 MHz. The configuration of detectors downstream of the targets are: a silicon vertex detector for reconstruction of decay vertices; a tracking system for momentum measurement; and lepton (e, μ) and hadron (π, K and p) identification systems consisting of an electromagnetic calorimeter, gas ionization chambers interleaved with iron plates, and a Ring-Imaging Cherenkov counter (RICH). Detailed descriptions of these detectors can be found elsewhere.[2]

2. High-P_T Trigger System

The objective of the high-p_T trigger system is to identify high-p_T hadrons. This is done by selecting high-p_T track candidates in an event based on the hit patterns in the trigger chambers with a pad-type readout placed within the spectrometer magnet. The hit positions determine "regions-of-interest" in downstream tracking

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chambers which are used as seeds for a Kalman-filter tracking algorithm in the First Level Trigger (FLT).

The high-p_T tracks typically bend little or make larger angles with respect to the beam direction, and their hit patterns in the trigger chambers are distinct from those caused by minimum bias tracks. The p_T distribution for tracks from two body decays of $b\bar{b}$ and minimum bias events are shown in Fig. 1. This difference in the p_T spectrum has been exploited in the design of this trigger system.

The high-p_T trigger chambers (12 in total) with pad readout are organized as follows: six gas-pixel chambers[3] for the region nearest the beam, and six straw-tube chambers with pad readout[4] for the larger outer region. Half the chambers are located on the $+x$ side of the beam and half on the $-x$ side. For each side, the six chambers are positioned at three different distances from the target (along the beam direction); these are referred to as the PT1, PT2, and PT3 stations. The inner chambers have a total of 11960 channels and an angular acceptance in the bending view of $10 < \theta < 60$ mrad. The outer chambers have a total of 6240 channels and an angular acceptance of $40 < \theta < 250$ mrad. The gas-pixel chambers were constructed at ITEP, Moscow. The outer straw tube chambers were constructed at the University of Cincinnati and Princeton University.

3. Implementation of the Trigger Scheme

The nominal high-p_T track pre-selection is based on a 1-3-2 coincidence algorithm: combination of one pad in PT1 with three pads in PT2, and each of the three pads in PT2 with two pads in PT3. A sketch of this triple-pad-coincidence scheme is shown in Fig. 2. The scheme is implemented in the trigger electronics and can be modified in situ depending on the background level. Based on the 1-3-2 algorithm, the Monte Carlo estimation of trigger efficiency for pions from $B \rightarrow \pi^+\pi^-$ decays is shown in Fig. 3. With an input data rate of 2×10^{11} bits per second, the high-p_T trigger system is expected to process approximately 3×10^{12} coincidence patterns (for 1-3-2 algorithm) per second and send the kinematic information to the FLT. At an interaction rate of 40 MHz, the typical output data rate is expected to be $\mathcal{O}(10^7)$ messages per second. The high-p_T trigger logic hardware is designed to successfully handle 1.5×10^8 messages per second.

References

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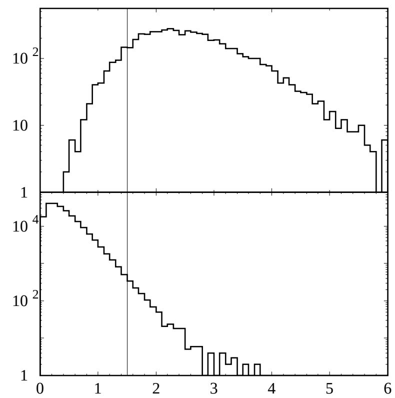

Fig. 1. *Momentum (GeV/c) distribution of pions from* $B^0 \rightarrow \pi^+\pi^-$ *decays (upper plot) and of tracks from minimum bias events (lower plot). The vertical scale is (N/0.02) GeV/c for both plots.*

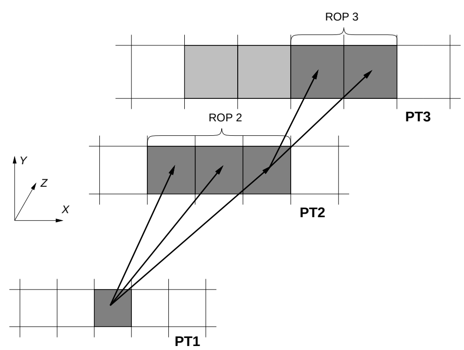

Fig. 2. *Sketch of the pad coincidence algorithm for the PT1, PT2, and PT3 chambers.*

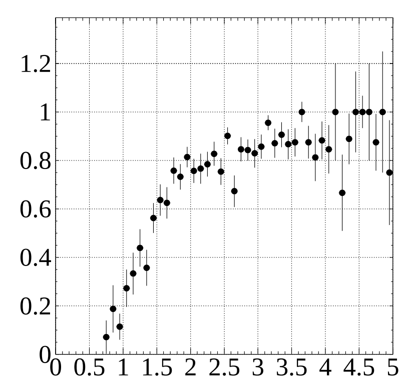

Fig. 3. *The trigger efficiency versus the* p_T *(GeV/c) of the track.*